

Applicant Remarks

Restriction Requirement:

Applicant respectfully traverses the restriction requirement because the claims as amended all relate to the spray electrode having a point focus provided by a rounded edge in order to avoid the generation of multiple jets which can occur with conventional electrospray devices. Performing a search on this basis would require no extra burden on the Examiner as he would merely need to search for electrospray devices having a point focus produced by a rounded edge. Although claims 1 to 3 specify aspects whereby the focus is provided by a projection, a rod and an oblique surface of the spray electrode itself this would not directly affect the overall search strategy to be employed by the Examiner. The Applicant respectfully traverses that there is any “serious burden” on searching with regard to Species III, IV, V and VI. The Examiner lists these species as being drawn to claims 2-3, 6-7. Given that all three “species” are covered by the same claim, it does not follow that there is any “serious burden.” With regard to the restriction requirement made final, Provisionally, Applicant elects, with traverse, to examine Species III.

Prior Art:

Applicant respectfully notes that the claims as amended are distinguished from the cited prior art for the following reasons:

The term “electrospray” relates to the atomisation of a liquid which is electrically charged during the spray event. Charging of the material often occurs immediately before it is atomised, most usually by direct contact with an electrode at a predetermined electrical potential. Atomisation may be promoted by pump or air-pressurised movement through a suitable nozzle. Alternatively, atomisation may be achieved by formation of a so-called Taylor Cone as the result of the generation of a high specific surface on the material by application of the high electric field to that material. The Taylor Cone creates a jet of atomised charged material. The present application relates to Taylor Cone electrospray and this is clear from the Figures of the application.

In electrospray of liquids, it is important to control the spray event and to minimise the number of jets formed under the applied electric field. Multiple jets are undesirable since they affect the trajectory and flow rates of liquids that are sprayed, leading to instability and poor performance reproducibility.

Controlling of the likelihood of multiple jets can be achieved for a single liquid by adjusting the geometry and voltage potential of the electrical set-up. However, this is not commercially feasible for electrospray devices which may be required to spray more than one liquid. It is an object of the invention to control and restrict the formation of multiple jets without requiring rearrangement and resetting of the electrical set-up for different liquids to be sprayed. This object is achieved by providing a capillary spray electrode modified such that it has a focus which is

less sensitive to formulation changes in the liquid and where performance is more consistent over long periods of use.

Capillary spray electrodes of the art include spray electrodes formed from capillaries cut perpendicular to the longitudinal axis and those electrodes formed by forming a bevel on the exposed end of a capillary. Whether the end of the capillary spray electrode is cut perpendicular to its longitudinal axis or at an oblique angle to the same, the problem of multiple jets is not eliminated.

Therefore, capillaries are not inherently suitable for single-jet electrospray for a range of liquid formulations to be sprayed. The focus of the electric field moves from a co-axial point to the sharp edge of the cut. The electric field does not focus at a point focus, but rather along the "knife" edge. The result is that there are many sites from which a jet could form and multiple jets arise as a consequence.

The Applicant discovered that by providing a capillary electrode characterised in that the capillary edge is rounded such that the electric field strength drops away rapidly from the focal point of the electric field, multiple- jetting can be prevented. A focal prominence can be achieved by providing a capillary characterised in that it comprises a bevel, the edges of which are rounded so that the electric field drops away rapidly from the focal prominence. Preferably, the radius of curvature of the rounded edge is less than that of the spray electrode. This is reflected in the amended claims 1 to 3 which are directed to aspects where the focus is provided

by a projection, a rod and an oblique surface respectively. In each aspect, the edges of the focus are specified as being rounded or having rounded edges.

Considering the art cited by the Examiner, US 3735925 describes a method and spray device for purported electrostatic spraying of material. There are several fundamental flaws with the cited art that make it irrelevant to Taylor Cone jet electrospray.

First, the large electrical potential difference between the two electrodes (1 and 4) of the device of US3735925 would not charge the material to be sprayed as taught by the Applicant, but rather would merely polarise it. Any charge acquired by the material as it travels between the electrodes (1 and 4) is acquired by direct contact with a conductive portion of one electrode (1). Rather, the jet electrospray condition might arise if there existed an electric field between the exit end (9) of the device and the object (11) to be sprayed. For this to happen, the object (11) must be at different potential to the material at the exit end (9).

US3735925 states at column 4, lines 52-65 that the end piece (6) is connected to (1). Therefore the end piece (6) is at the same potential as electrode (1) and the material at exit end (9). However, the object (11) to be sprayed is also at this potential, meaning that the jet electrospray condition cannot exist with use of the device described in the '925. Therefore, the '925 does not disclose that the electric field causes the spray.

Alternatively, if the object (11) is grounded (therefore end piece (6) is grounded), the circuit is shorted and any charge acquired by the material to be sprayed by virtue of its contact with electrode (1) leaks away immediately, preventing the jet electrospray condition.

Moreover, since end piece (6) does not have any current passing through it and is not excited, it cannot be an electrode.

Further or in the alternative, the end piece (6) comprises a sharp rim equivalent to the "knife" edges of capillaries of the art. Therefore the presently claimed invention is not anticipated.

Further or in the alternative, the focal point (if any) of electric field generated at exit end (9) is dependent on the changeable orientation of the exit end (9) to the planar surface of object (11), there being no disclosure (or incentive) in the art to limit their relative positions to achieve a single focus of electric field or to avoid multiple jet electrospray.

In any event, the presently claimed invention relates to jet atomisation by electrostatic spraying through generation of a high specific surface of a liquid. By way of contrast, US3735925 achieves atomisation of charged material by pressure of material itself or by pressure of compressed air (see column 5, lines 45 to 53). For the above reasons, not all of the claim limitations are present in the cited art and therefore the art does not anticipate under §102.

Considering US6776844 cited by the Examiner, for the reasons set out above, the sharp edges of the flying electrode (3-1) prohibits focus of electric field to a single point since the electric field strength along its edges is defined predominantly by the smallest radius of curvature i.e. the very sharp edge of the capillary exit. Therefore, the electrodes of US6776844 provide the ideal electric field shape to create multiple jets, which is contrary to the purpose of the presently claimed invention. The '844 simply does not provide an electrode that has a focus of a single point. Therefore, Applicant's claims are not anticipated by the '844. In addition, the '844 does not render Applicant's claims obvious. The principle of the '844 is entirely different: it does not use a focus to prevent a multiple streams. The focus is not an "optimum value" obtained by "routine skill". The patent specifically states that "The flying electrode 3-1 has a sharp pointed shape, and is held so as to keep a narrow gap from the organic EL display." [4, 4]. Therefore, the patent does not suggest to one of ordinary skill in the art to change the sharp shape to one that is rounded because that would change the operation of the prior art device. "If the proposed modification or combination of the prior art would change the principle of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims prima facie obvious. In re Ratti, 270 F.2d 810, 123 USPQ 349 (CCPA 1959)" MPEP 2143.01.

With regard to claim 2 as amended, it specifies that the spray electrode "is provided with a focus" rather than "has a focus". That is because with Claim 2, the focus is

"provided by a rod adjacent to the spray electrode". The rod is an entity which may or may not be integral to the structure or housing of the spray electrode itself. For that reason, Claim 2 stands an independent claim to Claim 1.

Rejections over §112: The Applicant believes that the claims, as amended address the concerns of the Examiner with regard to §112.